



Bitumen emulsions: Meeting the pavement preservation challenge



Abstract

This paper aims at describing the pavement preservation challenge: funds restriction, social demands and environmental regulations.

Thanks to their moderate cost, bitumen emulsion techniques are back on the stage. Technical developments have been carried out in the past years with remarkable achievements such as:

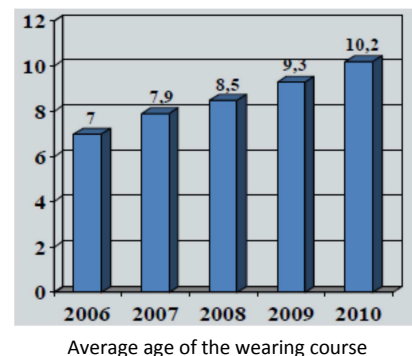
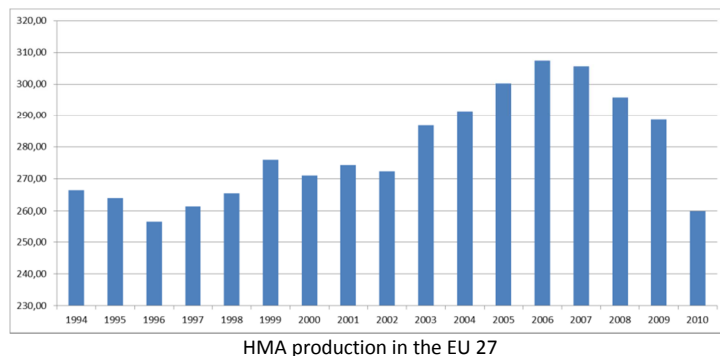
- Trackless tack coat
- Cold in place recycling 2nd generation
- Heavy duty chip seal

The specific characteristics of the bitumen emulsion techniques also contribute to implement safe and environmentally sound solutions.

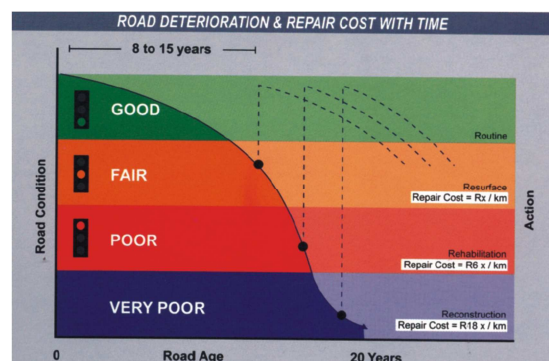
Introduction

The European road network gathers 6.1 million km of roads that carried 73.8% of the good transport inland and 85.3% of the passenger transport in 2009¹. Such a road asset needs to be maintained in order to ensure the growth of the economy and the welfare of the population.

However, the economic crisis that has hit the World in 2008 has had a negative impact of the public budgets devoted to road maintenance. One of the visible consequences of such restriction is the sharp decrease of the hot mix production². Another way to assess the growing maintenance backlog is to assess the ageing of the road networks. The example below right shows a 3 year ageing within only a 5 year period³.



In other words, road owners are facing a growing challenge: how to maintain the road assets they are in charge of before it is too late. We all know that the more we wait the higher the bill.



For that reason, road owners have been forced to optimize the use of the funds they are in charge of by implementing pavement management systems that include the selection of techniques within a vast portfolio of reliable techniques⁵.

As a result, the emulsion based techniques are back on the stage, thanks to their reasonable cost, provided that their technical characteristics are appropriate. The purpose of this paper is to show how emulsions will contribute to meet the pavement preservation challenge, within the frame of a difficult context.

¹ European Road Statistics 2011. European Union Road Federation

² Source: EAPA

³ La programmation et les techniques d'entretien de la chaussée du conseil général du Var. Gérald Lacroix. Journées techniques routes 2012. Nantes (France). Février 2012.

⁴ Sabita. Asphalt news. Volume 21. Issue 1. May 2007

⁵ See in particular : Entretien et gestion des voiries départementales. Les innovations du département des Yvelines. Michel Borraccino Chef du Bureau programmation et gestion de la route (BPGR) Sous-direction Gestion et exploitation de la route (SGER) Direction des Routes et des Transports Conseil général des Yvelines & Didier Méheut Chef de la Mission politique technique (MPT) Direction des Routes et des Transports Conseil général des Yvelines RGRA | N° 888 • octobre 2010

technique	Slurry seal	Micro surfacing	Chip seal	UTFC	HMA
cost / yd ² \$	0.75 - 1.00	1.50 - 3.00	1.50 - 2.00	4.00 - 6.00	3.00 - 6.00

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technique	Micro surfacing	Micro surfacing 2 layers	Chip seal	Very thin asphalt concrete	HMA
cost / m ² €	2.04	3.04	2.33	6.20	7.90

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technique	chip seal one layer	chip seal two layers	micro surfacing	HMA 30 mm
cost / m ² €	2,30	4,00	2,45	4,14

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The global challenge

However, economy is one side of the three fold global challenge that also includes:

- Social demands
- Environment protection

This challenge was brightly described by Mr. Rt Hon Philip Hammond, Secretary of State for Transport, said during a speech he delivered in September 2010⁹,

« [...] the Coalition Government is committed to the sustainability agenda in everything it does, including transport. [...] we are all too conscious of the fact that sustainability means so much more than simply "carbon reducing".

Sustainable solutions have, of course, first and foremost to be environmentally sustainable. But they must also be fiscally and economically sustainable - affordable to the taxpayer in the long-term and compatible with an economic growth agenda.

And they must be socially sustainable as well - promoting social mobility and recognizing the aspirations of the least-advantaged in our society and of the billions of people trying to improve their quality of life in the less-developed nations of the world ».

This statement does not apply to Europe only. World leading economies such as the USA are facing the same challenges: "To meet the technical demands of Green Paving Industry, FIU established a Green Paving program in 2011. With some 2.7 million miles of paved roads in the United States, oil prices going up, roads aging and financial resources dwindling, Highway Agencies are faced with the challenge of sustaining such a vast asset. There are clear ways out of this mess:

1. Technologies to reuse existing material,
2. Technologies to prolong the life expectancy of roads, and
3. Technologies to reduce cost and energy demand of current construction process.

⁶ Guidelines for the Preservation of High-Traffic-Volume Roadways – Transportation Research Board Washington D.C. 2011

⁷ La programmation et les techniques d'entretien de la chaussée du conseil général du Var. Gérald Lacroix. Journées techniques routes 2012. Nantes (France) février 2012

⁸ Manutenzione stradale in primo piano. Alessandro Manni & Luca Rossi. Strade & costruzioni. Ottobre 2011

⁹ IBM START Conference: Business Summit 10 September 2010

Benefits of these technologies are estimated at 40% cost savings, 70% emissions savings and 100% reuse of existing materials. At a national level, these can translate into annual savings of \$18 billion of highway maintenance cost and thousands of tons of pollutants a year”¹⁰.

Emulsion based techniques often meet the sustainability challenge. Their global efficiency is constantly improving as shown in the following examples. More than a technique, bitumen emulsion is part of systems addressing the problem of pavement preservation.

Trackless tackcoat

The performance of an asphalt mixture overlay depends on the interface bond strength between the newly constructed asphalt mixture lift and the underlying pavement layers. A tack coat, which typically consists of bitumen emulsion, has been commonly used to achieve the necessary bonding between pavement layers and to ensure that they behave as a monolithic system that withstands traffic and environmental stresses. Poor interface bond strength may accelerate the appearance of distresses such as slippage and surface cracks. Several factors have been considered to affect the bond performances. Those are tack coat material type, tack coat application rate, pavement surface type, temperature, construction site conditions, and others.

One of the main problems the industry had to face used to be the integrity of the bond coat during the road works operations. One of the ways to deal with such is to use specific pavers, equipped with an integrated spray bar. However, such a solution means that all the conventional pavers should be replaced at high cost by a new generation of machines.

An alternative to this option is to play with the emulsion design, in such a way that the binder will not stick to the truck tires and the paver caterpillars or wheels, while adhering to the existing layer.

Several techniques have been developed in order to reach this goal. All these techniques are based on two principles:

- Quick breaking emulsions
- Increased softening point of the residual binder

Increasing the softening point of the residual binder may be achieved either by the use of a hard grade bitumen (say 35/50) or by the modification of the binder with a polymer.

Specifications have been developed in some countries like Japan in order to characterize this type of emulsions, together with appropriate tests to qualify the “adhesion ratio to tires”¹¹.

Some experiences are also reported about slow setting emulsions used on milled surface that give much better results than quick set emulsions. In that case, the emulsion remains unbroken and not damaged by the traffic, thanks to the shallow cavities left by the milling operation¹². Such a system contributes to neutralize the remaining dust particles that cannot be removed by the sweeping equipment.

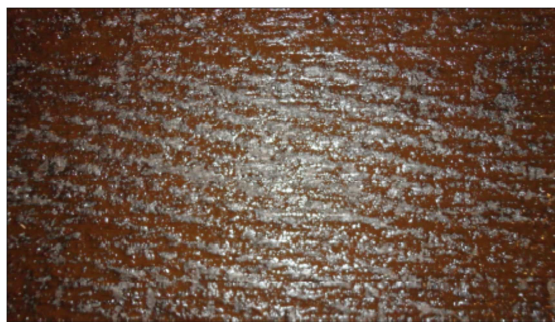
¹⁰ Green Paving Initiative. Florida International University. Feb. 2012.

¹¹ PPRA Newsletter 2011#4

¹² Source : COLAS



Rapid Setting emulsion 65 %



Slow Setting Emulsion 60%

Cold in place recycling

Cold in place recycling has been used worldwide for decades. However, and as recalled above, protecting the environment, reusing natural resources and endeavoring to make our lives better have become major development priorities. Increased respect for the environment means saving non-renewable resources and valorizing the materials in the existing roadway, while limiting the need to use new materials.

Technically wise, cold in place recycling using bitumen emulsions is a true reliable technique that has been assessed through numerous studies. As an example, the average modulus measured on cores by the Ponts et Chaussées Regional Laboratories for bitumen emulsion recycled asphalt mix is roughly 4,000 MPa (direct traction test at 15°C and 0.02 seconds). It is important to note that the level of modulus does however depend on the type of materials being recycled (untreated aggregates in particular). As an example, measured in diametral traction, the equivalent modulus at 15°C, 10 Hz of materials recycled after 9 and 10 years under traffic is shown in the following data. The structural effect is very satisfactory and suited to the traffic levels the roadway must bear¹³.

location	Age (year)	Compaction ratio (%)	E* (15°C 10 Hz) MPa
RN 20	10	90.0	4,050
RN 145	9	89.2	6,500

From an environmental point of view, the advantages of recycling techniques are known:

- Saving of virgin materials
- Saving of transportation
- Saving of energy

Such positive impact has been assessed by the use of the SEVE tool, developed by the French Road Industry (Union des Syndicats de l'Industrie Routière Française) within the frame of the CEV [Voluntary Commitment Agreement], signed on 25 March, 2009 in order to be able to present environmental comparisons of the technical solutions they are offering to project owners by creating an "Eco-comparer" shared by the companies.

The USIRF has been given the task of arranging the development of this tool that enables the signatories to compare the environmental impacts of the offers for their customers. The software is called SEVE (Système d'Evaluation des Variantes Environnementales) [System for assessing eco-friendly alternate bids].

The initiative is based on two main aspects:

1. Setting up a set of guidelines that are auditable and validated by an external body such as the ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie) [Environmental Agency Responsible for Energy],

¹³ Michel Bertaud & Michel Ballié. In place bitumen emulsion recycling of roadways : technical & environmental report (2008)

using current standards (Life Cycle Analysis, etc.) and based on values and coefficients set by recognized professional bodies;

2. Development of a software tool implementing these guidelines and enabling them to be put to practical use. Such guidelines relate to environmental impacts connected with roadworks and environmental indicators deal with greenhouse gas emissions (in kg equivalents of CO₂, energy consumption), the preservation of natural resources and consumption of RAP (for recycled asphalt pavement)¹⁴.

SEVE has been extensively used within the frame of the European TRACC project (Road techniques adapted to climatic changes). It is a transnational project, with members from Spain, Portugal and France¹⁵.

The TRACC Project deals with the promotion and the development of road techniques adapted to climatic changes. It started with an assessment of the environment friendly road techniques already currently used in the program area. Then a special work on innovating techniques and a socio-economic and environmental study was conducted. Amongst its deliverables, it included a guide for road owners, aiming at integrating environmental aspects in their road projects. Most of the techniques that have been studied within the frame of TRACC deal with bitumen emulsions that save energy, materials, and use recycled materials and, as a result, generate less pollution.

The project ended in December 2011. Its main outputs have been presented in Toulouse (France) on March 2nd, 2012.

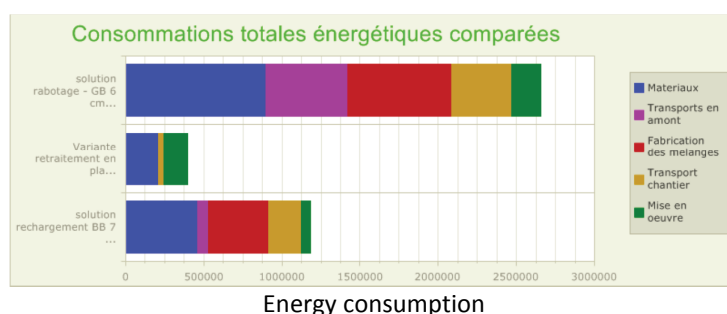
One of innovations that were presented is the “second generation” cold in place recycling process, that consisted in assessing the feasibility of recycling of an already recycled pavement. The trial site was done on RD 125 (Haute Garonne, France), dealing with 8000m² of pavement. The technical solution was:

- Cold in place recycling using emulsion 8 cm deep
- Wearing course using a micro surfacing

Two technical equivalent solutions were considered:

- Placing a 7 cm thick layer of hot mix asphalt
- Milling and placing a 6 cm of road base asphalt + very thin overlay (2.5 cm).

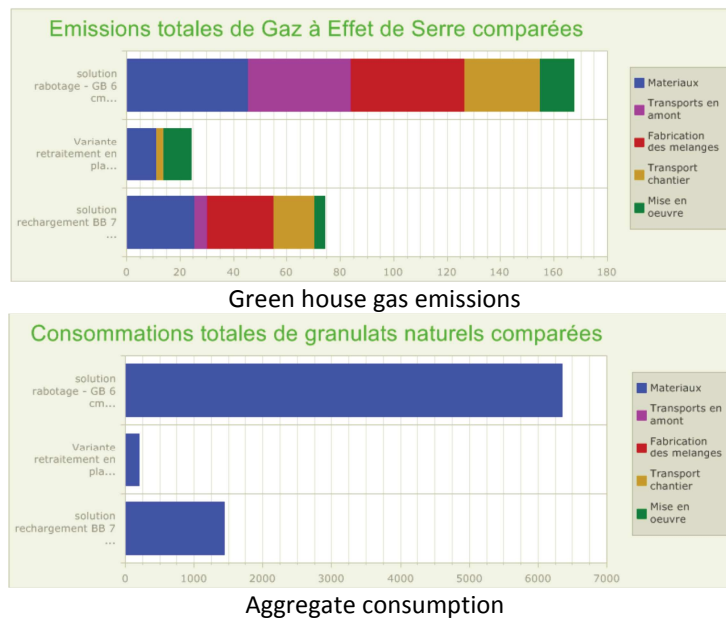
Once the technical feasibility has been demonstrated, the environmental assessment was conducted with the following results¹⁶:



¹⁴ SEVE : the new tool for road builders companies. Christine Leroy (Usirf), Estelle Brosselier (Charier), David Fallone (Eiffage Travaux Publics), Vincent Grossenhy (Colas), Marc Jakubowski (Malet), Serge Kraft (Eiffage Travaux Publics), Henri Molleron (Colas), Stéphane Quint (Eurovia), François Verhee (Usirf). (2010)

¹⁵ Conseil Général of Haute Garonne, Junta of Castilla y Leon, Laboratoire Régional des Ponts et Chaussées of Toulouse, Sines Technopolo and Institut Polytechnique de Setubal, Syndicat Professionnel Régional de Industrie Routière Midi Pyrénées, Asociación Técnica de Emulsiones Bituminosas).

¹⁶ André Clarac (Colas). Bagnère de Luchon – RD125 – France : Retraitement en place à froid à l’émulsion de bitume de 2^{ème} génération (2012)



All graphs clearly show the positive impacts of the cold in place recycling technique. But more than that, it quantifies such impacts, translated into figures.

A new generation of chip seal: new equipment, improved components

Chip seal is one of the oldest pavement preservation techniques. It is also one of the most economical one.

Hot spray and emulsion based chip seals have been used for years throughout the world, with a heavy trend in favor of emulsions, thanks to three main factors:

- The cost of fluxes and solvents used in hot sprays has been permanently increasing during the past years
- Safety regulations make hot spray uneasy to handle, while emulsions are used at ambient temperature
- Environmental demands from the various stakeholders, translated into regulations, lead the professionals to more and more consider the use of bitumen emulsion, including in countries such as South Africa, New Zealand and Australia that have a long tradition of hot spray¹⁷. In countries such as the United Kingdom and Ireland, bitumen emulsion is the sole material used for chip seal.

Moreover, within the frame of budget restrictions, many road owners are moving back to this technique, using advanced systems:

- Installation equipment

A new generation of spraying machines and spreading devices has been used now for several years. Such equipment includes integrated systems combining the binder spraying and the aggregates spreading. Such systems allow reaching an optimum wetting of the aggregates by the emulsions and, as a result, an optimum adhesion between the aggregates and the remaining binder. Moreover, IT systems are used that guaranty a constant rate of binder whatever the spraying width and the equipment speed. Some systems are even fitted with an ultrasonic gauge that permanently measures the distance between the spray-bar and the surface, a back regulation ensuring this distance to be constant. Such a system contributes to obtain a fully even distribution of the binder on the surface.

¹⁷ Resealing with bituminous emulsions in the A.C.T. Peter Thompson, ACT Government – Roads ACT, Australia and Dante Cremasco – Downer EDI Works Pty Ltd, Australia. 2nd International Sprayed Sealing Conference – Sustaining sprayed sealing practice, Melbourne, Australia 2010



Computerized system



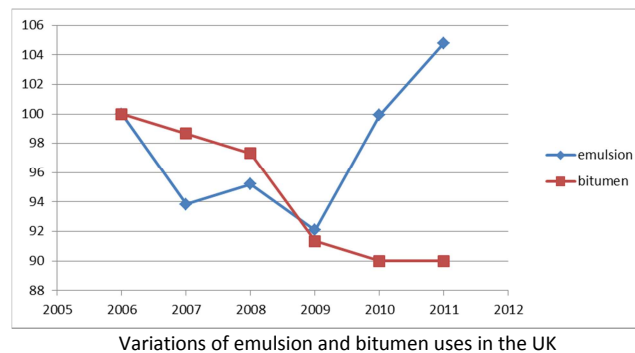
Dual machine

- Design

The increasing loads that the surface wearing courses have to bear request the use of improved binders, such as:

- Modified emulsions using natural latex (SBR) or synthetic polymers (SBS)
- Combination of emulsion and fibers

The use of modified emulsion has been significantly developed in countries where the technique is properly mastered and implemented. This is the case in the United Kingdom where 80% of the emulsions used for chip seal are modified. Such a control has contributed to the success of the emulsion industry, within a depressed road industry, as shown in the diagram below.



Chip seals contribute to the imperviousness of the pavement. They also restore the skid resistance of the surface, contributing to the safety of the road users. They can also be used as SAM and SAMI, with additional resistance brought by fibres that are added into the sprayed emulsion. In a single operation, specialist machinery cuts and applies the glass fibres between two layers of emulsion to form a sandwich type matrix. Selected aggregates are then added via a purpose built or conventional chipping spreader. Application is completed by rolling and sweeping, leaving a crack and fatigue resistant surfacing characterised by enhanced tensile strength. These techniques have been used in Europe and also in the USA, with official recognitions such as "avis technique" in France¹⁸.

Conclusion

In many countries, pavement preservation budgets are hit by budget restrictions and most likely this situation will last for the years or decades to come. Moreover, social demands from the stakeholders and environmental requirements have added to the technical challenge the road industry has to meet. In the meantime, the duty of the governments, at each stage, is to ensure that the road networks are kept in good condition.

¹⁸ Avis technique 146 Colfibre® March 2007

Within the frame of such a stringent context, road owners, road authorities and the road industry have worked for years for the development of technically sound products and processes that will contribute to make the best use of the allocated budgets.

Bitumen emulsions are part of these solutions, with developments that contribute to address the multiple issues. A new generation of tack coats – bond coats - , cold in place recycling and an range of improved chip seal systems are examples of such developments.